Investigation of Desiccants and CO_2 Sorbents for Advanced Exploration Systems

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Background

- Desiccant beds have shown moisture breakthrough failures during use on station but show no pellet degradation issues
  - Better desiccants are desired, if available
- ASRT is the active CO_2 removal sorbent used onboard the ISS, but can no longer be manufactured
  - The search for replacements is ongoing after the first selection, RK-38, failed to remain resilient
- Replacement sorbents must remove as much CO_2 in cyclic operation as ASRT while maintaining integrity over a thousand days of use
  - Performance and reliability must be well understood

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Selection Criteria

- Material Strength
  - Minimal dust generation when subjected to compression and abrasion in dry and humid conditioned states
- Capacity
  - Equal or greater adsorption than ASRT
    - At 10°C and 2 torr CO_2
- Reliability
  - Must not irreversibly lose CO_2 capacity after exposure to moisture and attempts to reactivate at system temperatures

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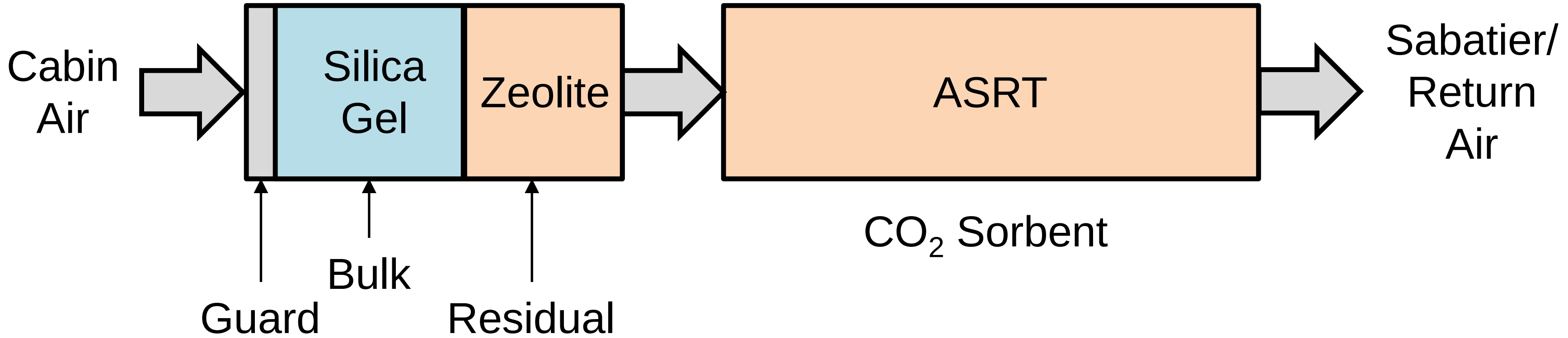
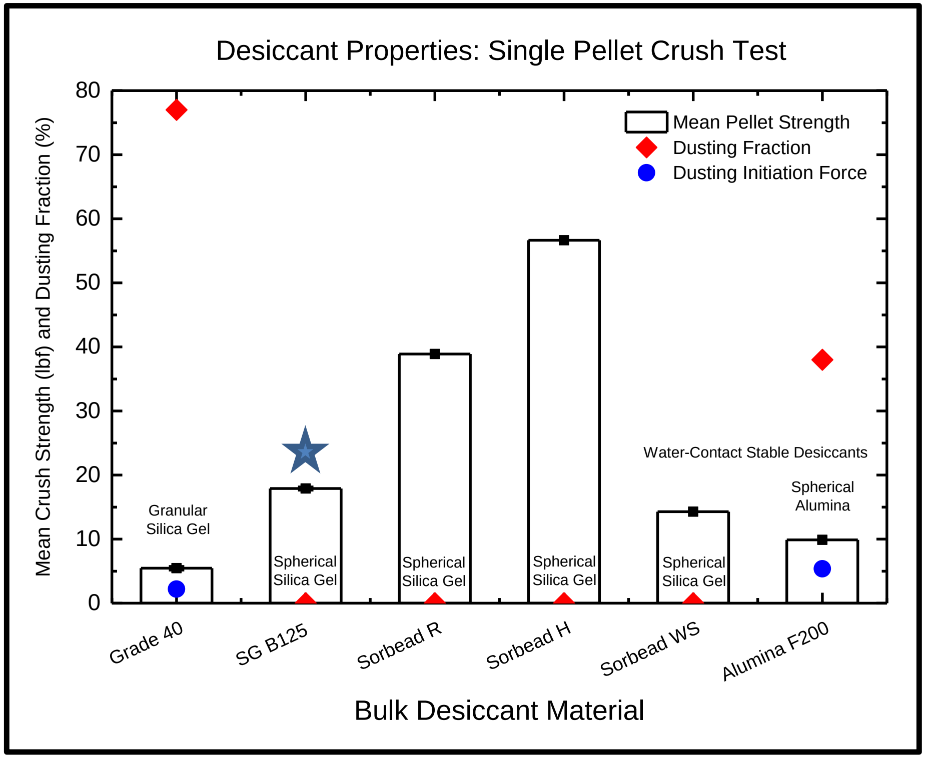
CDRA Desiccant and CO_2 Sorbent Beds



Bulk Desiccant Selection

Structural Properties

- Returned flight beds showed no problems
  - Pellet strengths in excess of present material is not necessary
  - Zero “dusting” is highly desirable
- Current material is
  SG B125



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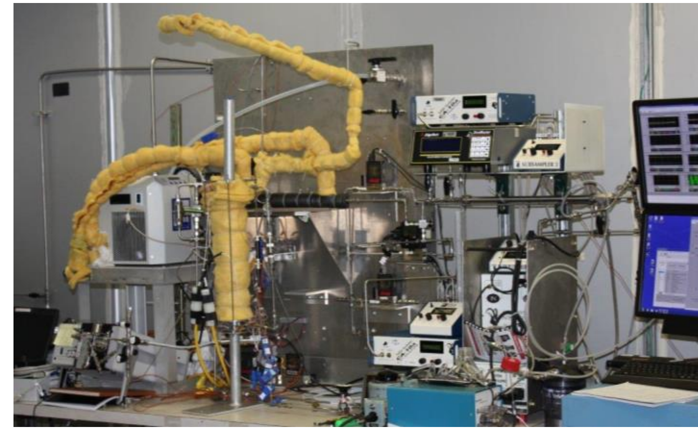
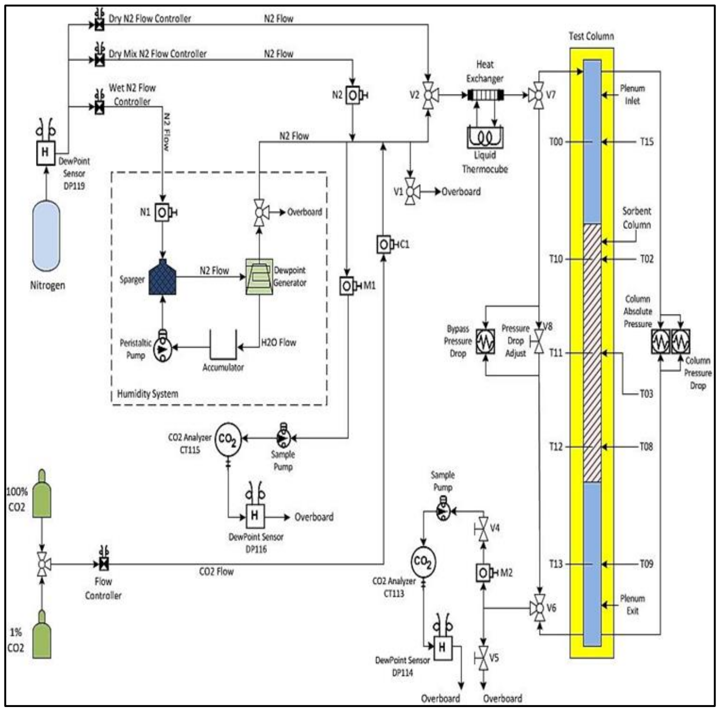
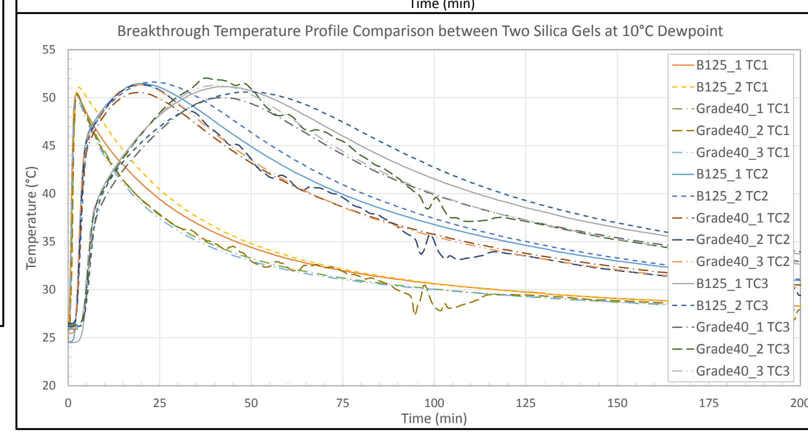
Bulk Desiccant Selection

Adsorption Properties

Cylindrical Breakthrough Test Stand







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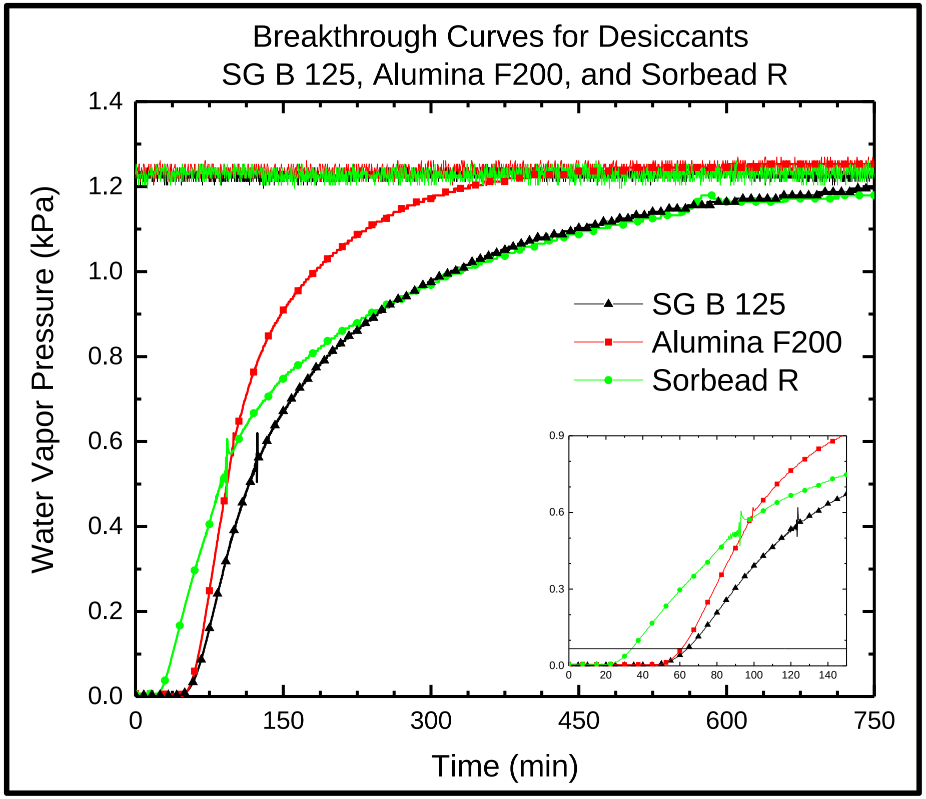
Bulk Desiccant Selection

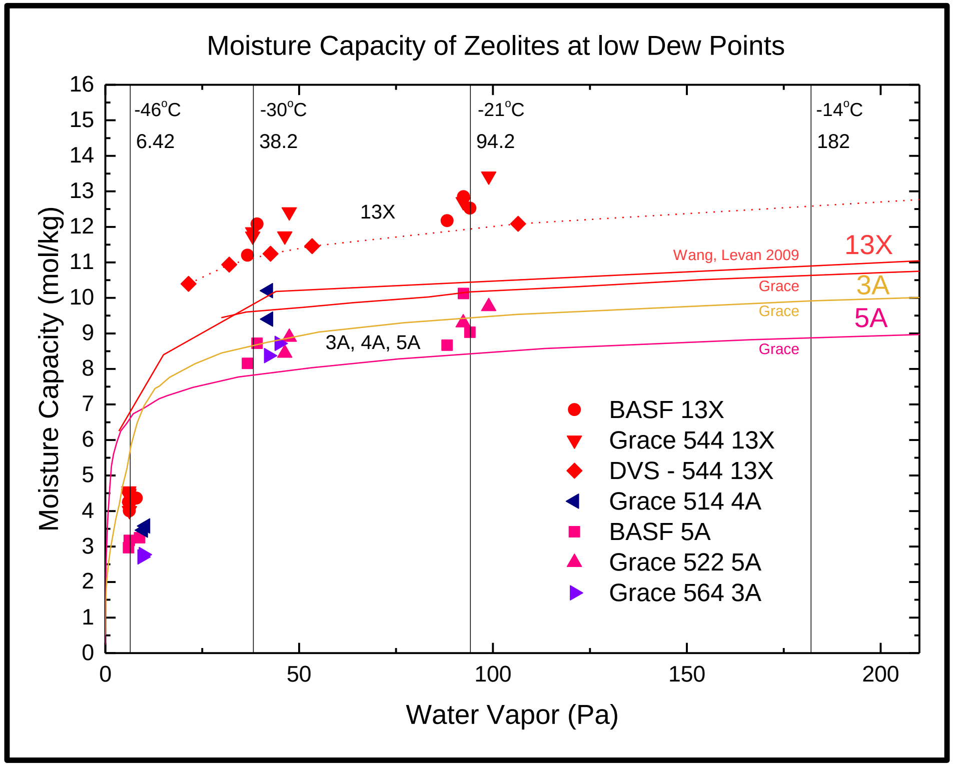
Adsorption Properties



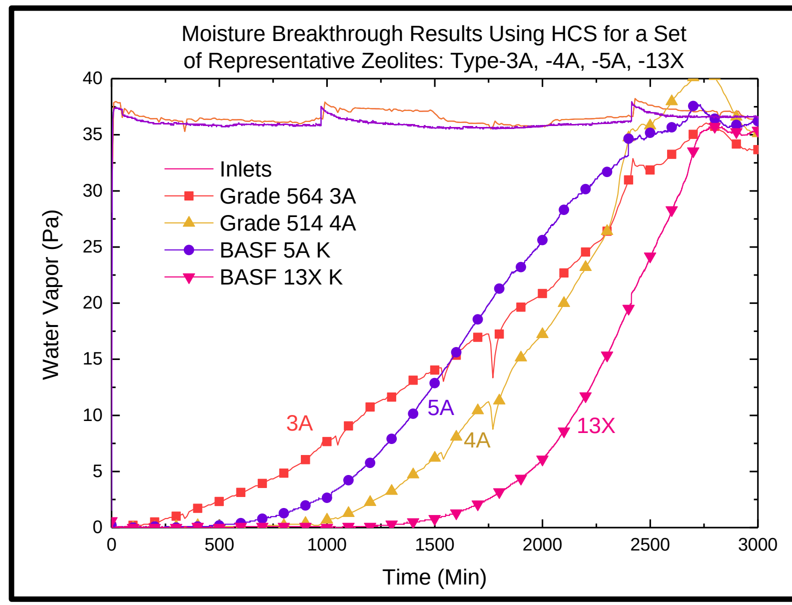
- Breakthrough capacity at 25°C and a dew point of 10°C can be related to desiccant bed performance
- SG B125 has the best moisture capacity "per bed volume"

Residual Desiccant Selection

Adsorption Properties



- Breakthrough capacity at 20°C and trace dew points to study relative performance



- Measured on Humidity Conditioning Test Stand

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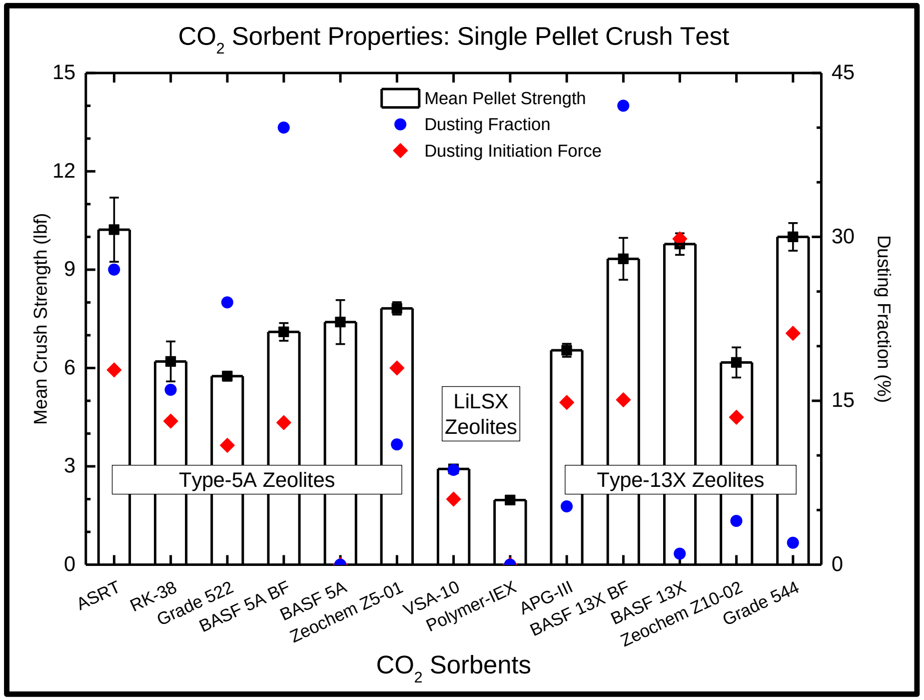
CO_2 Sorbent Selection

Structural Properties

- Single pellet crush testing is an ideal initial screening test
  - Test can be conducted on sample-size quantities of material
  - Useful to eliminate high dusting materials
  - Results are informative but not predictive of 4BMS performance alone
- Measured on Autosorb-1c



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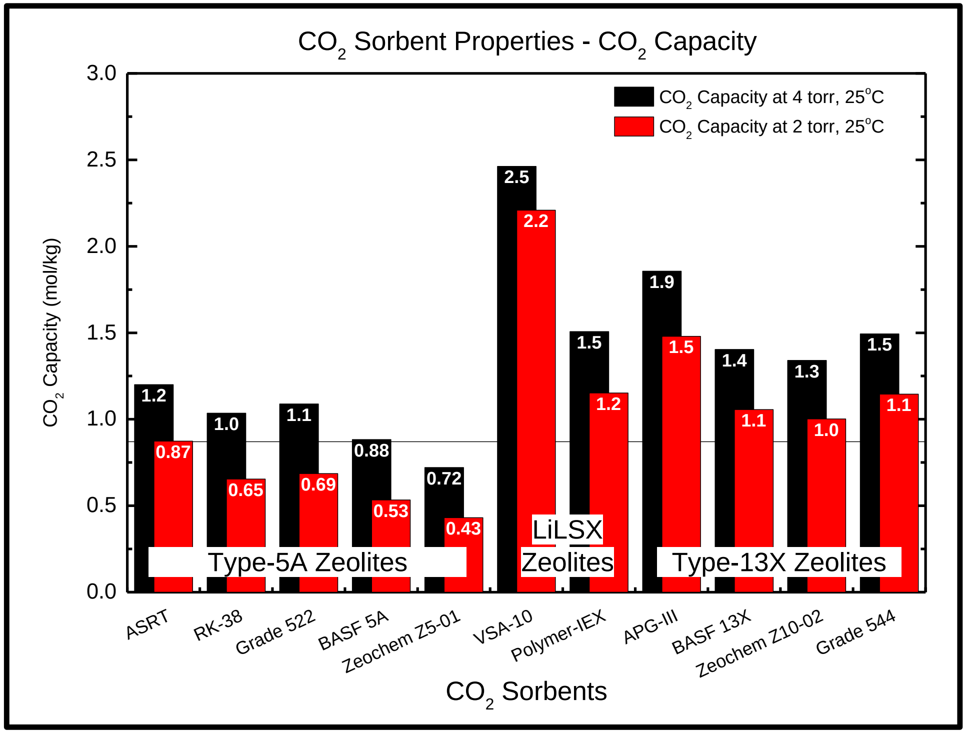
CO_2 Sorbent Selection

Adsorption Properties



- Replacement must exceed ASRT for CO_2 capacity
- 13X and LiLSX zeolites are prime candidates

- Measured on Autosorb-1c

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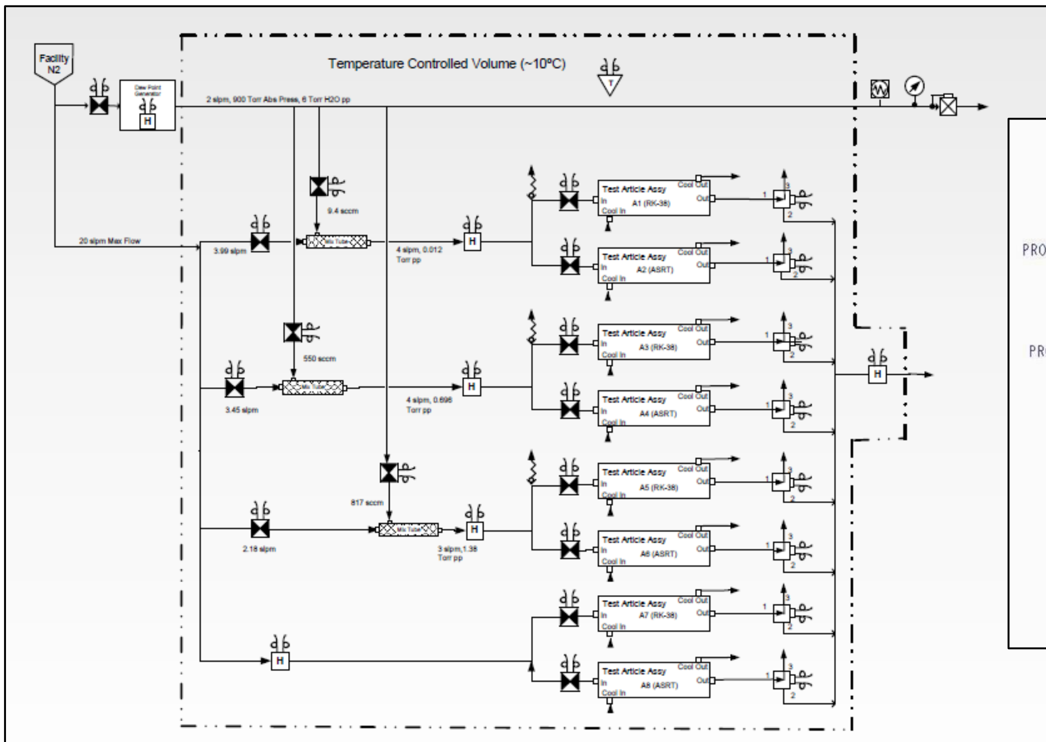
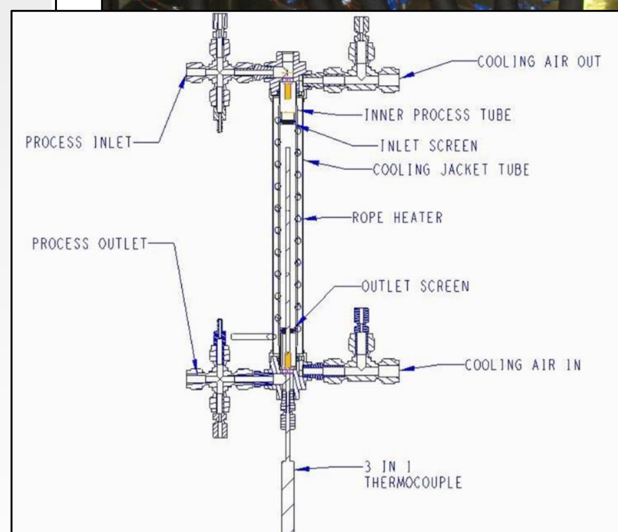
CO_2 Sorbent Selection

Reliability

Moisture Risk Assessment, pt. 1

Hydrothermal Stability Test Stand





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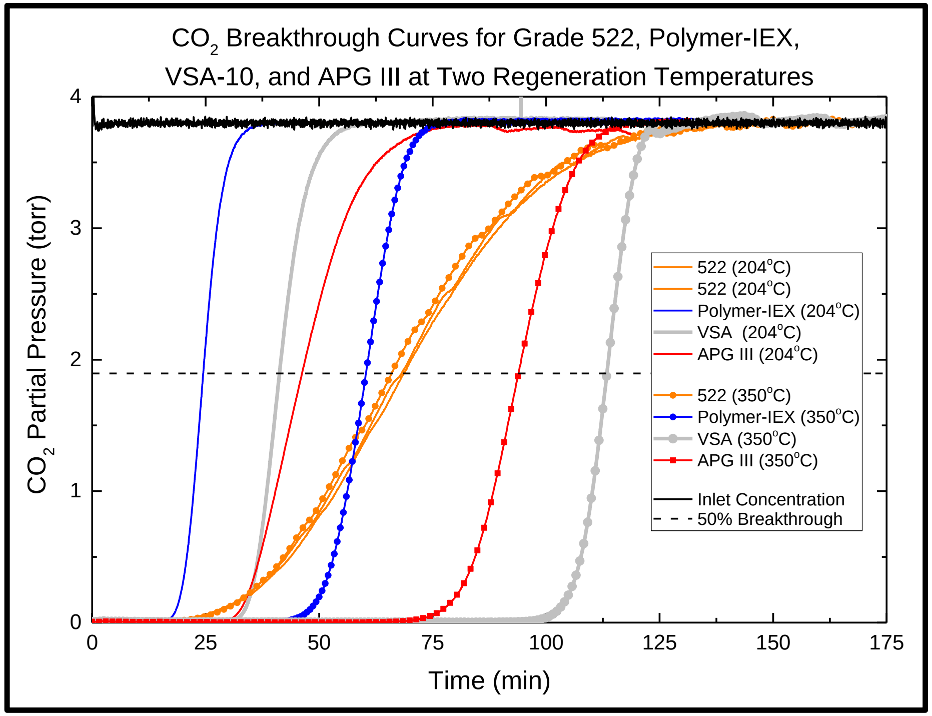
CO_2 Sorbent Selection

Reliability

Moisture Risk Assessment, pt. 1

- CO_2 dynamic capacity was measured before and after saturation with water at -21°C D.P. and reactivation
  - Recovery at CDRA temperature (204°C) led to a sharp loss of CO_2 capacity for some zeolites



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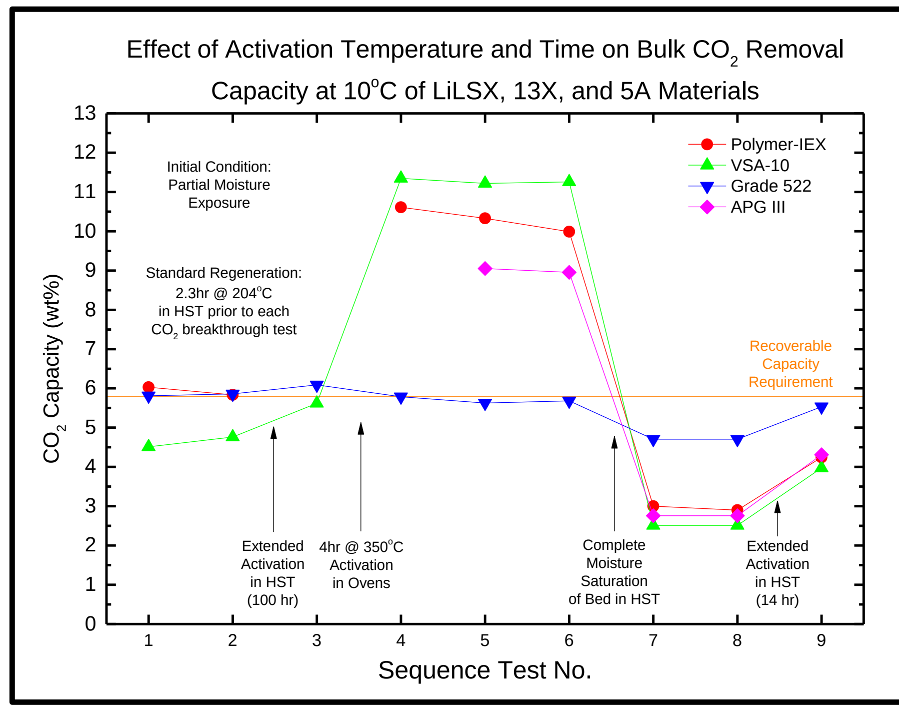
CO_2 Sorbent Selection

Reliability

Moisture Risk Assessment, pt. 1

- Comparing bulk removal capabilities
  - 5A zeolite recover most and eventually all CO2 capacity
  - 13X and LiLSX zeolites drop by a factor of 4 in capacity and show little recovery over time



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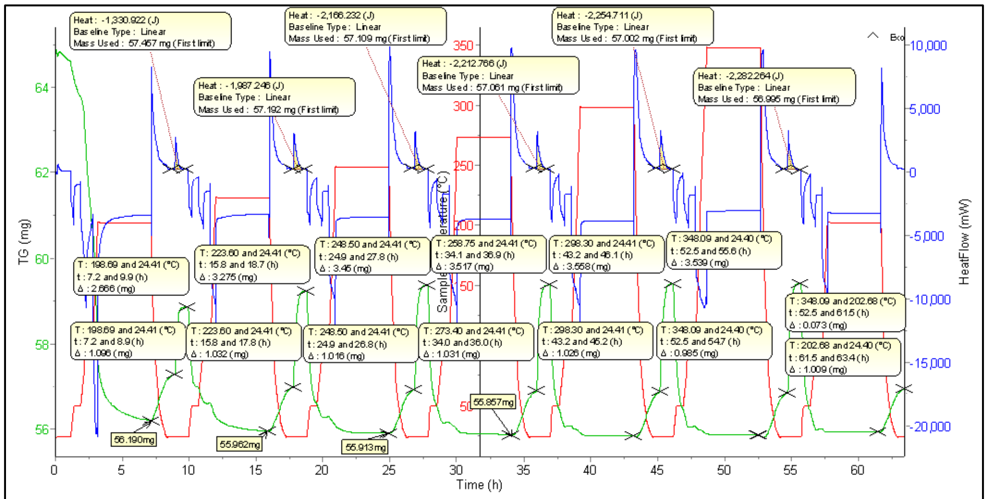
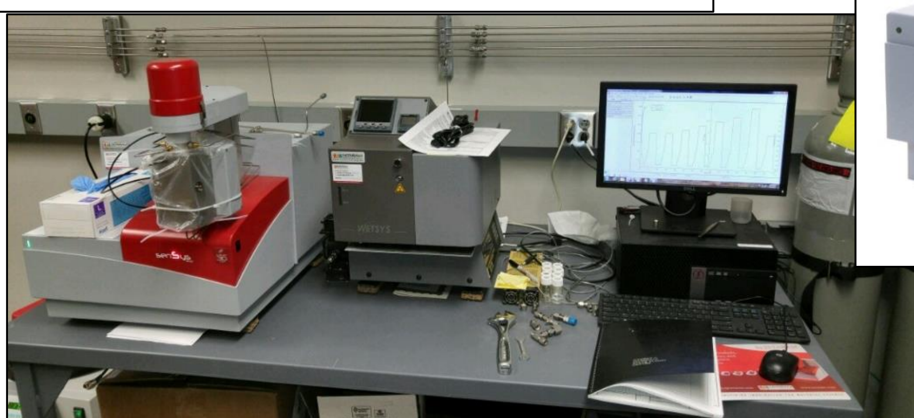
CO_2 Sorbent Selection

Reliability

Moisture Risk Assessment, pt. 2



SETARAM Sensys Evo TG-DSC



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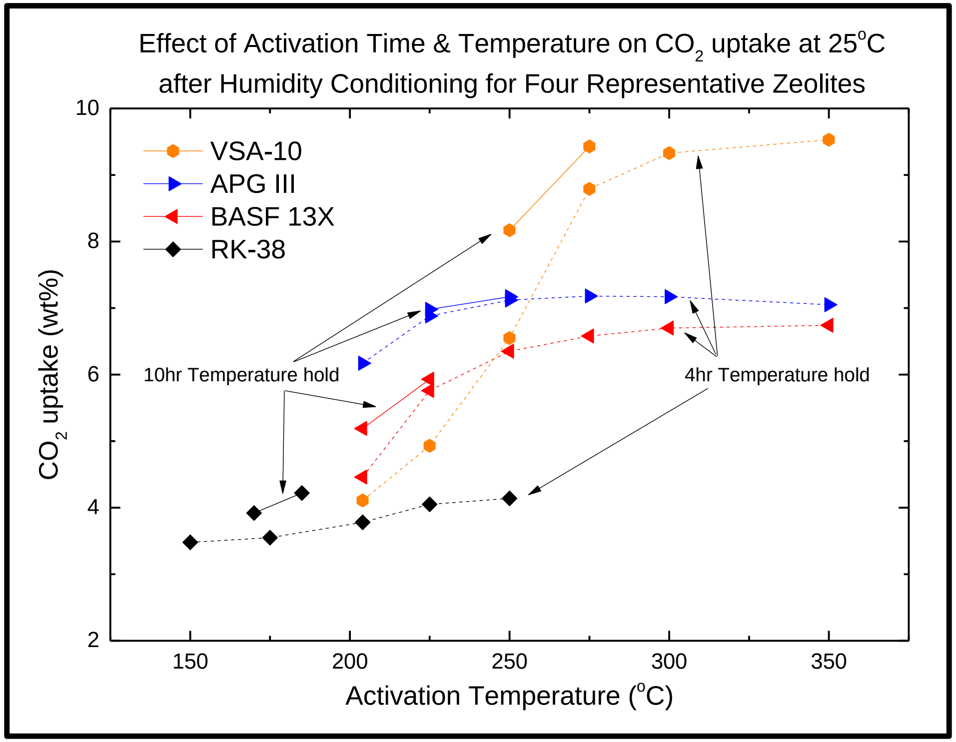
CO_2 Sorbent Selection

Reliability

Moisture Risk Assessment, pt. 2



- CO_2 <u>equilibrium</u> capacity was measured before and after exposure to water and reactivation
  - At 204°C and all higher temperatures, 5A zeolites had the lowest capacity

Conclusions

- The present bulk and residual desiccants show no performance issues and no candidates warrant selection over these

- Most likely candidate for future 4BMS CO_2 sorbent is a type-13X or LiLSX zeolite
  - System design considerations must be made for activating this material due to the possibility of moisture intrusion
  - Extended structural characterization in the hydrothermal stability test stand will be a critical factor
  - Alternative bed packing arrangements may forego the risks of moisture intrusion

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